JV 2020 and Beyond: Implications for Intelligent Support Architectures

The Boeing Company – Phantom Works

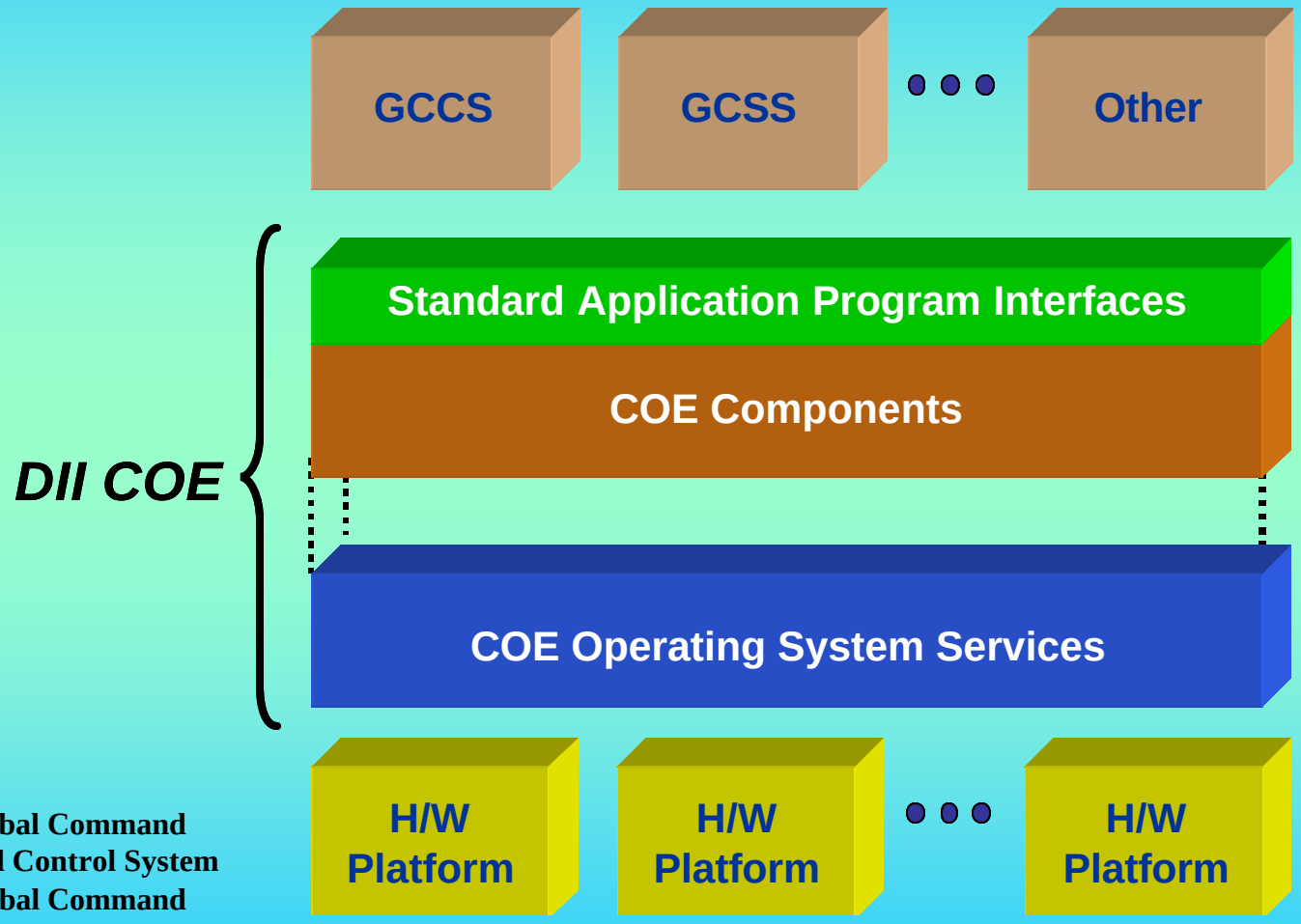
Dr. Kirby Keller, Technical Fellow,
kirby.j.keller@boeing.com, 314-233-2995, and

Timothy J. Wilmering, Associate Technical Fellow,
timothy.j.wilmering@boeing.com, 314-234-6781

Joint Vision 2020 and Focused Logistics

- **Fusion of logistics information and transportation technologies for rapid crisis response**
- **Ability to track and shift units, equipment and supplies even while en route**
- **Delivery of tailored logistical packages and sustainment directly to the warfighter**

Defense Information System Common Operating Environment (DII COE)

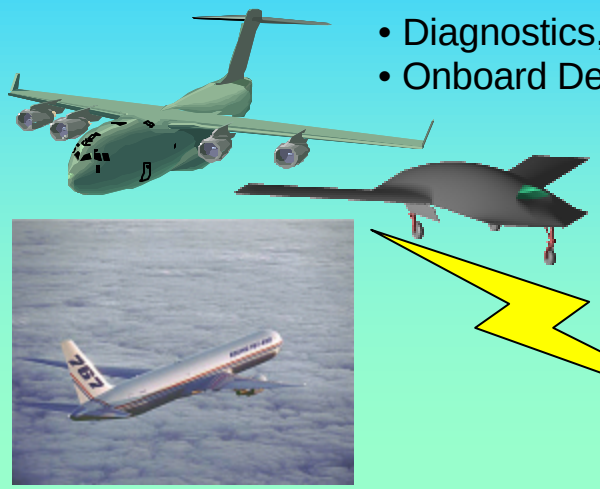


GCCS - Global Command and Control System
GCSS – Global Command and Support System

Advanced Support Functions

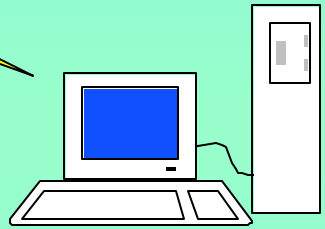
Onboard Health Management

- Diagnostics, Prognostics, Anomaly Detection
- Onboard Decision Support/Capability Models



Ground Based Health Management

- Diagnostics, Prognostics
- Maturation/Data Mining

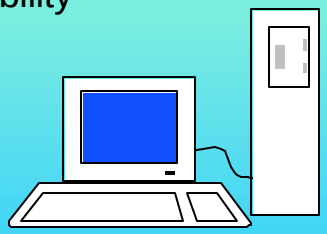


Logistics Planning

Spares, Transportation, Suppliers, Training, …

Commander Decision Aids

- Asset Availability
- Mission Readiness/Mission Capability



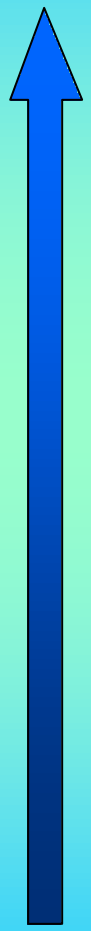
Informed Maintenance

- Scheduling
- Mechanics Heuristics
- Technical Data
- Maintenance Aids

Product Supports

Integrated Vehicle Health Management is How BIT Gets Better

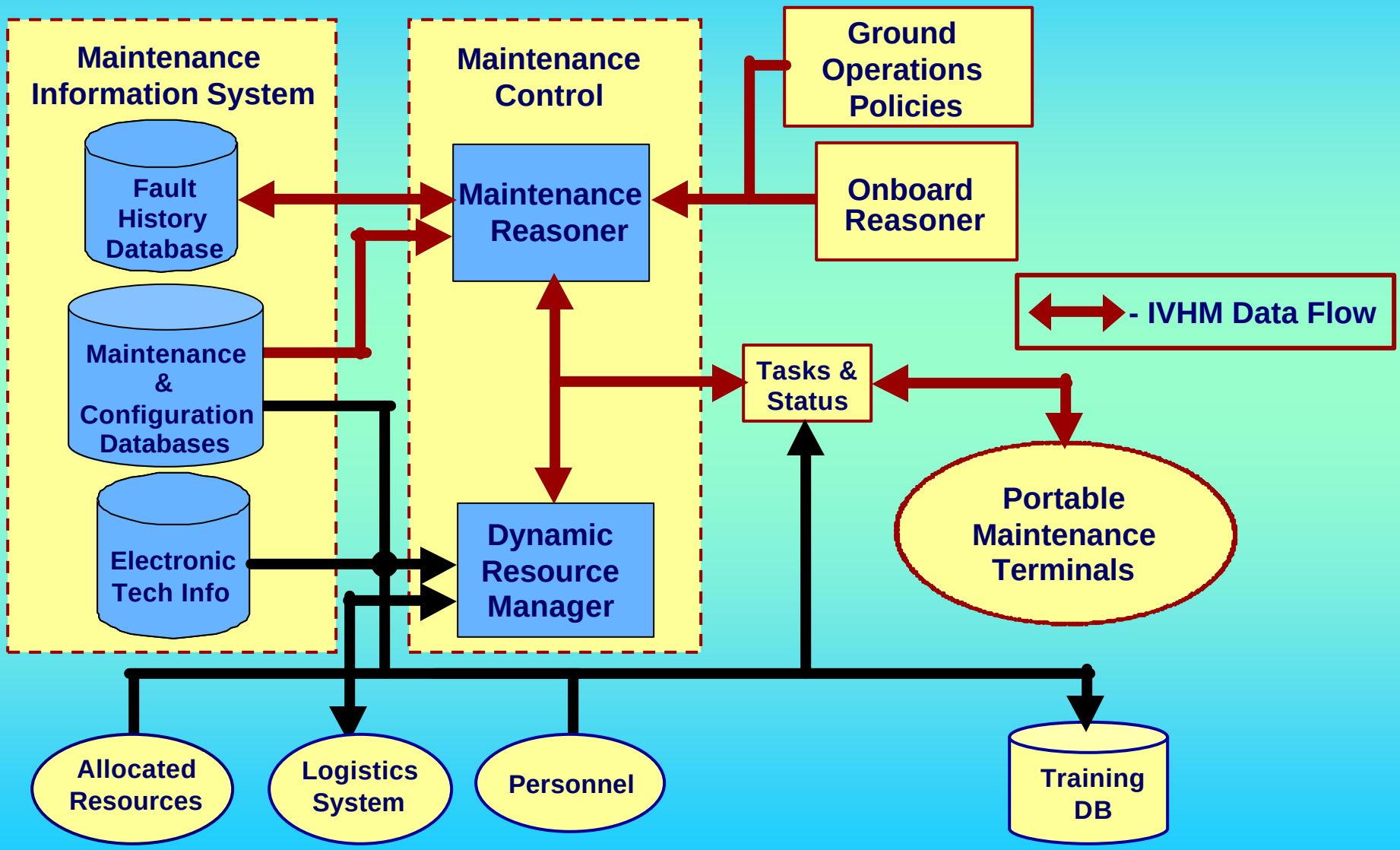
IVHM



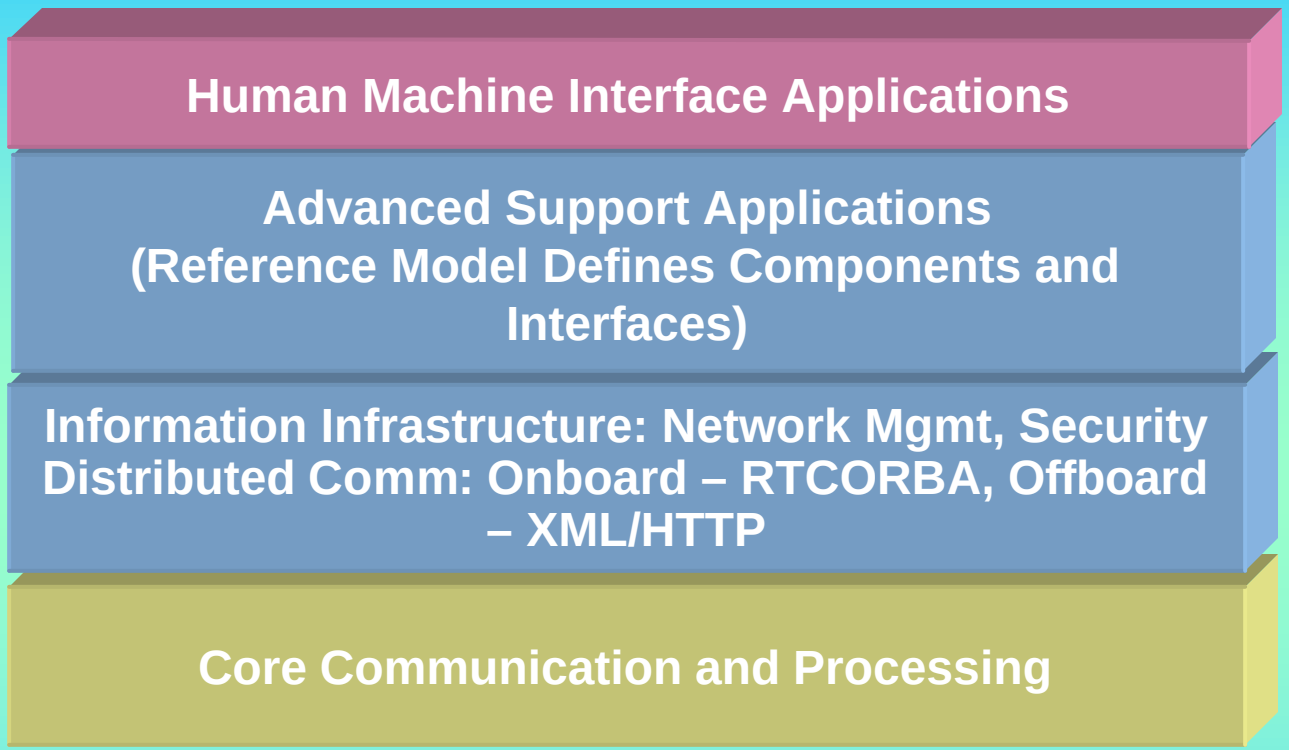
BIT

- Decision Support - Recommend Pull Based on Health, Operational Requirement and Maintenance Resources
- **Trending**/Degradation Models
- Unknown Fault/**Anomaly Detection**
- **Fusion, Event Sequence** Analysis
- Gray Scale Health Propagation
- System/Resource Management - Processing, Storage, Comm.
- Facilities to More Easily Update OMP
- **Closed Loop Process** to Calibrate and Mature Capability
- Context Correlation
- Higher Fidelity, **Gray Scale Monitoring** - Signal Processing and Additional 'Maintenance' Sensors (e.g. vibration)
- Greater Use of Context Models
- **Intelligent Data Collection** - Data Capture for Events
- **Model Based Diagnostic Development**
- **Integrated BIT** - Expansion of dependency graph, Captures fault propagation, tracks cascading and sympathetic faults
- Basic BIT - Threshold Limits; Local Dependency Modeling

Informed Maintenance

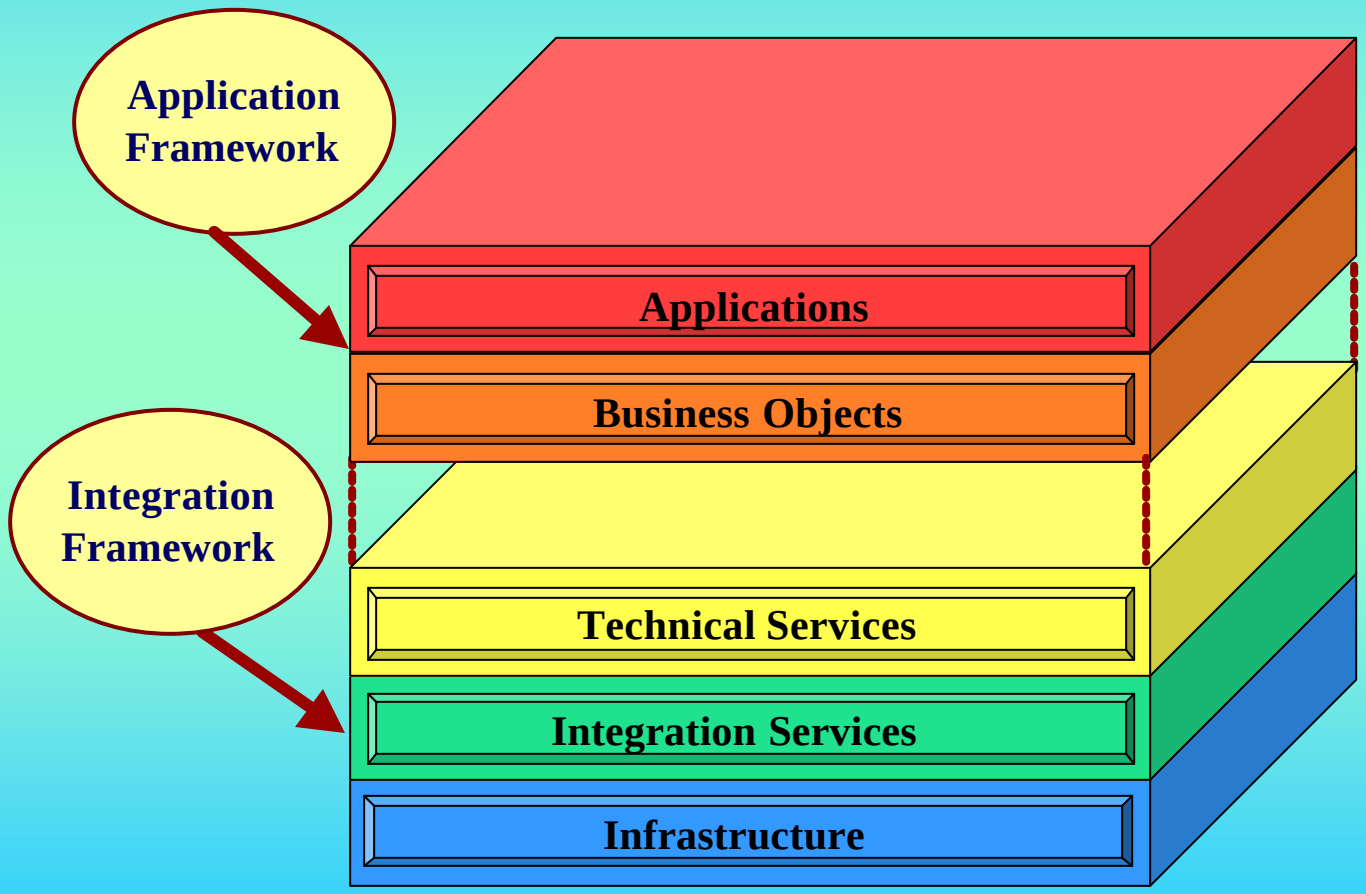


Open Reference Architectures



- **Interoperability**
- **Common Components and Reuse Reduce Development, Integration and Upgrade Costs**

Layered View of the GCSS-AF Reference Architecture



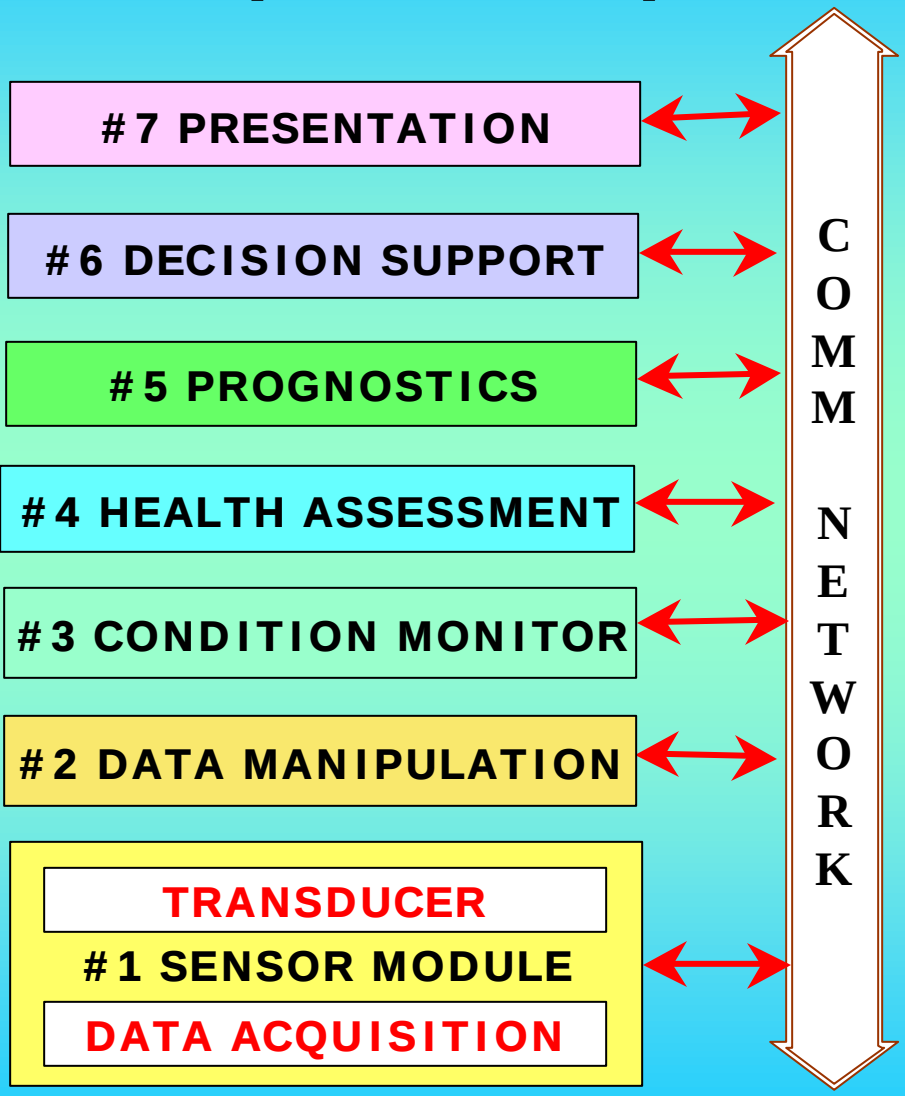
Open System Architecture for Condition Based Maintenance (OSACBM)

OSACBM Program: Dual Use Science and Technology (DUST) Sponsored by the Office of Naval Research and PEO Carriers. Completed in March 2002

Industry Consortium:
Boeing, Caterpillar, Newport News, Rockwell Automation, Penn State ARL, Rockwell Scientific, Oceana Sensor Technology and the Machinery Information Mgmt Open System Alliance (MIMOSA)

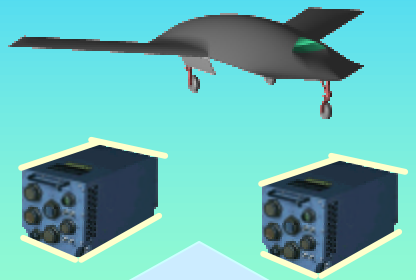
Objective: Develop Open Reference Architecture for Condition Based Maintenance (aka IVHM or PHM)

See OSACBM.org

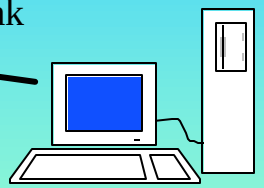


BOEING

IVHM System Implemented with OSACBM Architecture

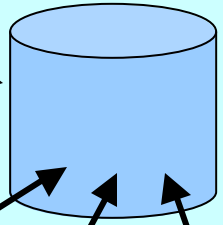


Data Link

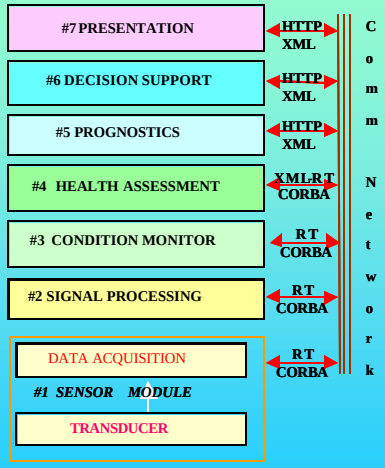


Mission Control Station (MCS)

Maintenance Data Warehouse



Operational Maintenance Program (OMP) Distributed within Vehicle and Mission Management Computer; Subsystem Controllers.

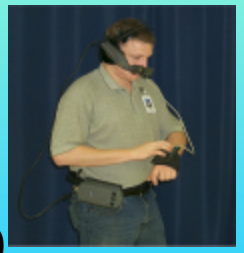


IVHM In Ground Based Reaonser

Ground Based Reasoner

Maintenance Reasoner (Informed Maintenance)

Portable Maintenance Terminal



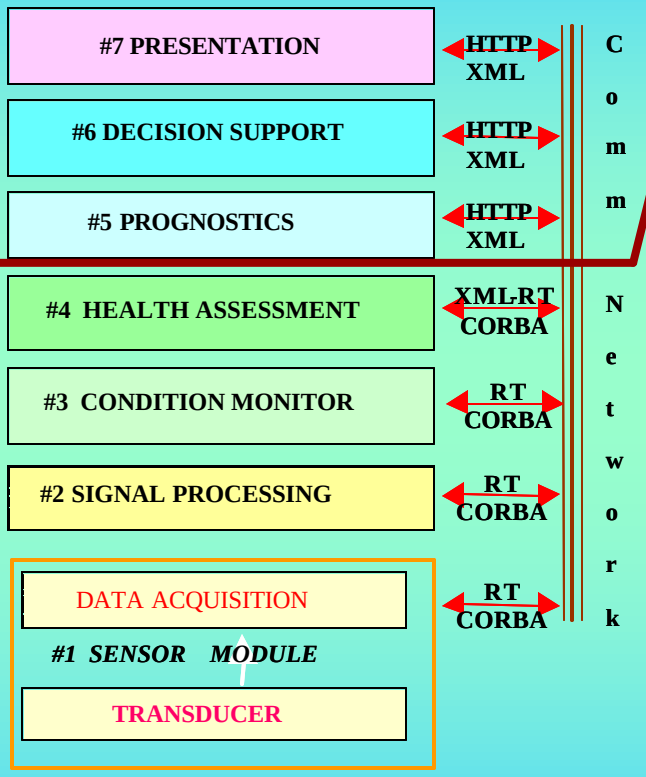
Representative Onboard IVHM System

Mapping to H/W

Mission Computer: Lower Data Rate Diagnostics

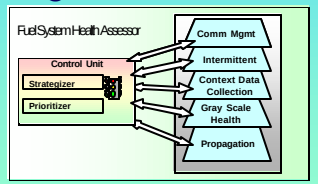
Vehicle Management Computer

Subsystem Controllers: Higher Data Rate (e.g. Power Distribution Unit)



Algorithms and System Services

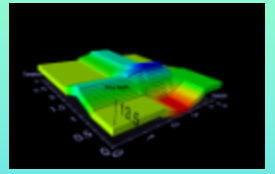
Module Control, Resource Management, Fusion/Integration



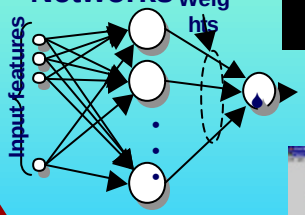
Causal Networks (Model Based)

Intermittents, Anomalies, Data Capture

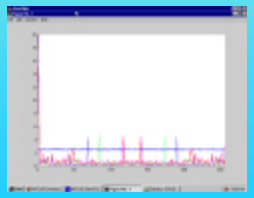
Fuzzy Rule Surface Fuel Valve Gray Scale Health



Neural Networks



Fast Fourier Transform



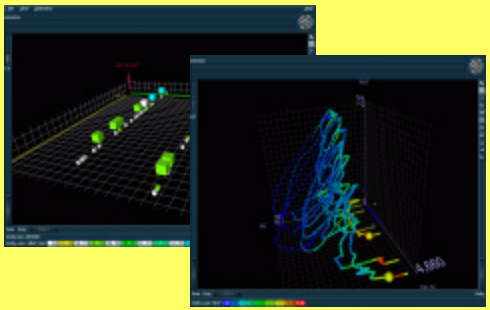
BOEING

Representative Ground Based IVHM and Informed Maintenance System

Maintenance Data Warehouse

New Records This Flight

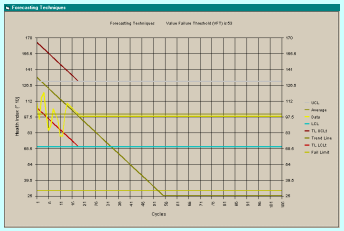
Past Records (History)



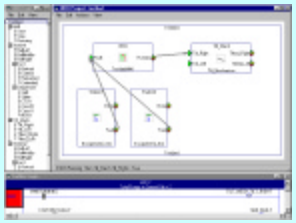
Engineering Analysis, Maturation (Data Mining)

Mechanics Heuristics
- Ambiguity
- Maintenance Induced Faults
- Interpreting Context Correlation (Bayesian Networks)

Prognostics/Trending (Statistical Process Control)

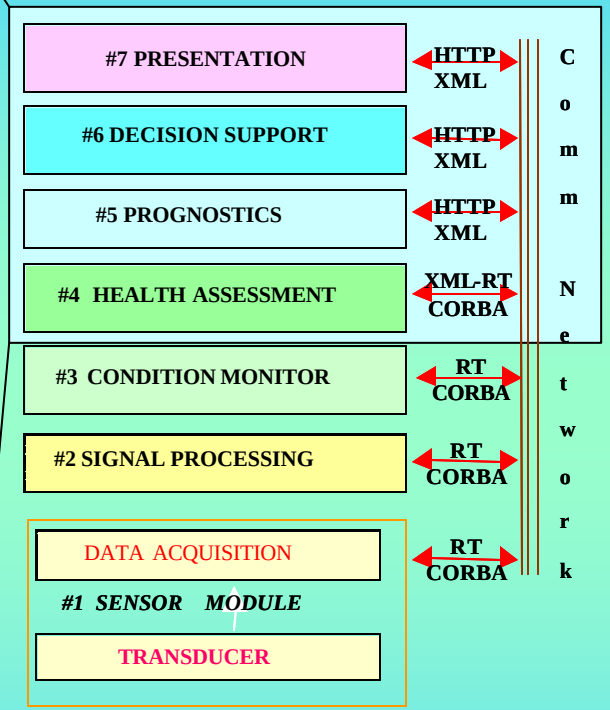


Model Based Diagnosis (Causal Networks)

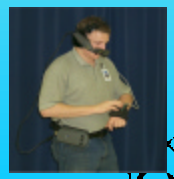


Faults
Degradations
RUL, Usage

S/W Reference Architecture



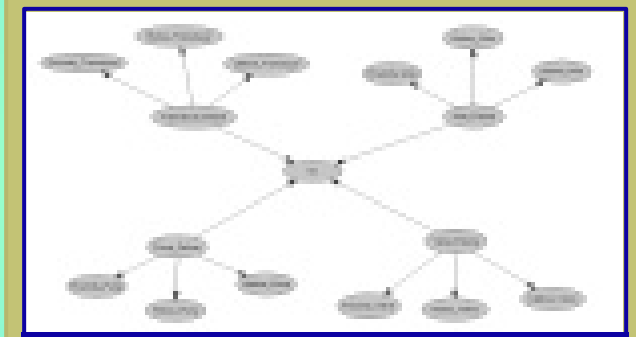
- **Maintenance Reasoning**
- **Resource Management**
- **Portable Maintenance Aid**



BOEING

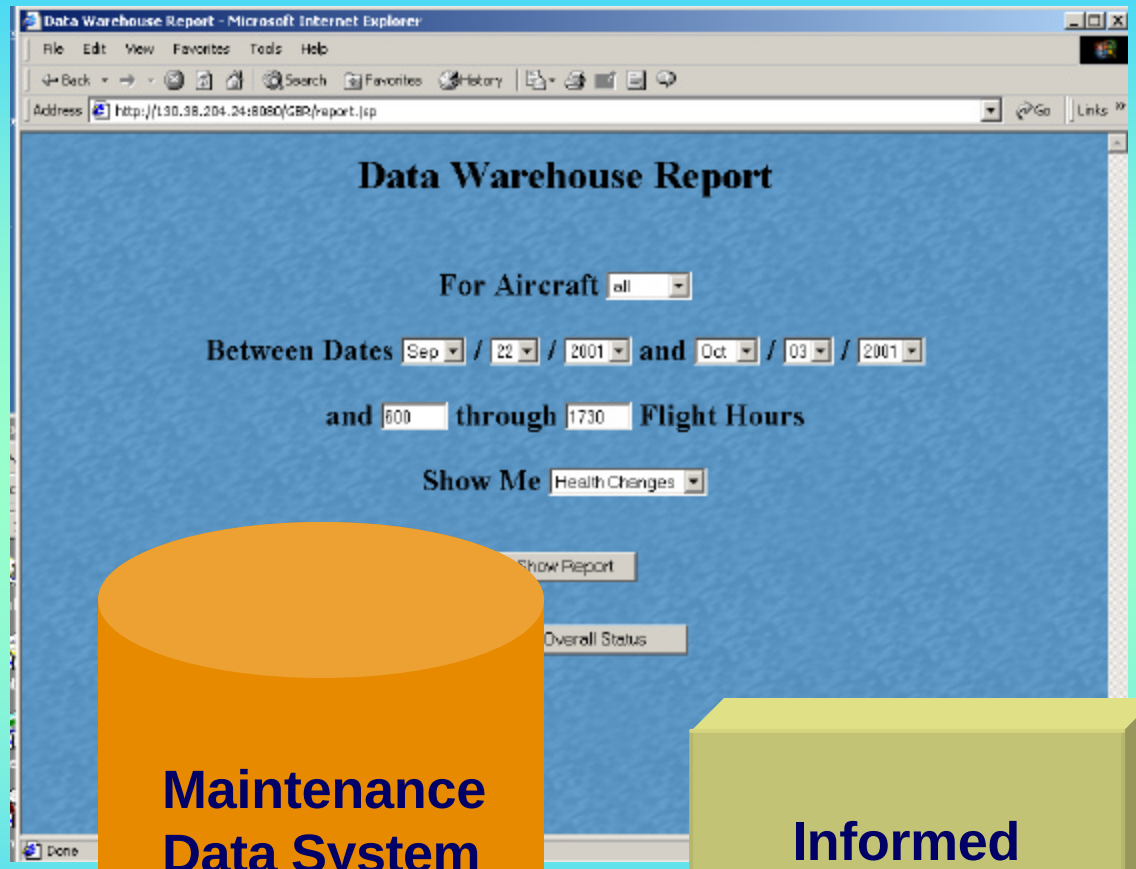
IVHM – Informed Maintenance Interface and Web Access

Ground Based Reasoner



Bayesian Network Model

Statistical Process Control Algorithms

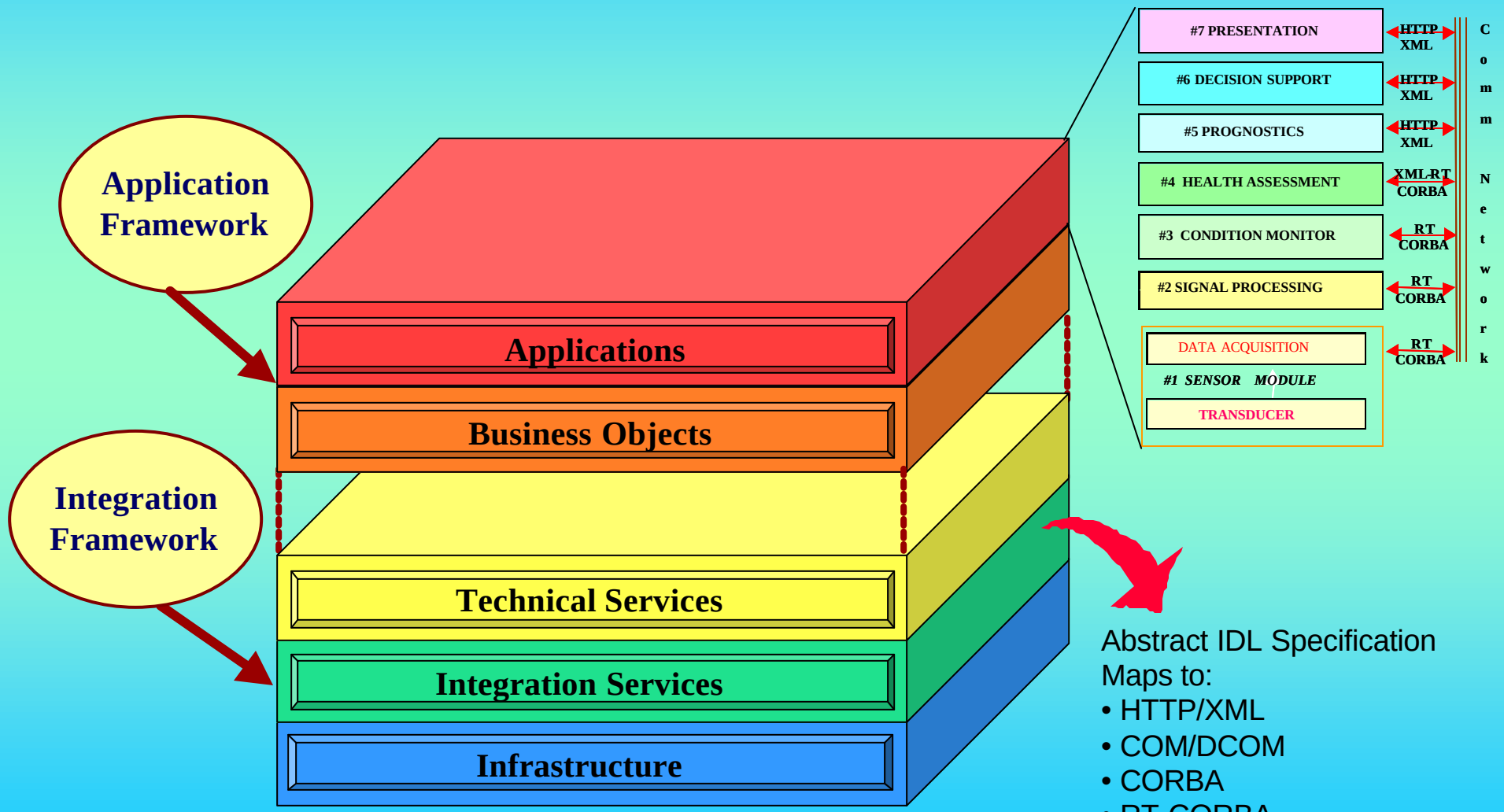


Maintenance Data System

Informed Maintenance

BOEING

GCSS Architecture Supports Intelligent Open Architectures



Abstract IDL Specification Maps to:

- HTTP/XML
- COM/DCOM
- CORBA
- RT-CORBA